Issued by the Colonial Office

EAST AFRICAN AGRICULTURAL RESEARCH STATION

AMANI

SIXTH ANNUAL REPORT 1933-34

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LONDON

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1934

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COLONIAL No. 100

88-303-0-34

CONTENTS

	Page
Staff List and Leave Movements	3
Publications	4
Visitors	5
Report of the Director	6
Report of the Plant Pathologist	
Virus Diseases of Plants	10
General	14
Report of the Entomologist	14
Report of the Soil Chemist	
General Survey and Classification	15
Special Studies of the Soil Groups	21
Erosion	23
Manuring	23
Miscellaneous	23
Report of the Biochemist	
Insecticides from Local Plants	24
Fermentation and Preparation of Coffee	24
Essential Oils	25
Acidity and Root Growth in Coffee Arabica	25
Other Work	25
Report of the Plant Physiologist	
Coffee Investigations	25
Sisal Investigations	27
Report of the Plant Geneticist	
Coffee	28
Sisal	30
General	31
Report of the Systematic Botanist	
Herbarium	32
Exchanges	35
Loan of Specimens	35
Field Work	35
Ornithological Work	38
Report of the Superintendent of Plantations	
Construction and Maintenance	41
Plantations and Nurseries	42
Plant and Seed Introduction	44
Plant and Seed Distribution	45
Report of the Secretary and Librarian	45
Appendix A—Financial Statement for the Year 1933	46
Appendix B—Publications	47

EAST AFRICAN AGRICULTURAL RESEARCH STATION

AMANI

Report for the Period 1st April, 1933, to 31st March, 1934

STAFF LIST.

Director.—W. Nowell, C.B.E., D.I.C., F.L.S.

Plant Pathologist.—H. H. Storey, M.A., Ph.D.

Entomologist.—T. W. Kirkpatrick, M.A., Dipl. Agric. (Cantab.), F.E.S.

Soil Chemist.—G. Milne, M.Sc., F.I.C.

Biochemist.—R. R. Le G. Worsley, A.R.C.S., B.Sc., Ph.D., D.I.C.

Plant Physiologist.—F. J. Nutman, A.R.C.S., M.Sc., D.I.C.

Plant Geneticist.—L. R. Doughty, B.Sc. (Agric.), N.D.A.

Superintendent of Plantations.—F. M. Rogers.

Secretary and Librarian.—R. E. Moreau, C.M.Z.S.

Botanist.—P. J. Greenway, F.L.S.

Assistant Superintendent of Plantations.—*Vacant.*

Assistant Secretary and Librarian.—W. M. Nutter.

Engineer-Mechanic.—T. V. Greenwood.

Laboratory Assistant (Pl. Path.).—R. F. W. Nichols.

Laboratory Assistant (Soil Chem.).—W. E. Calton, B.A., Dipl. Agric.

Stenographer.—(Miss) K. Rushworth.

LEAVE MOVEMENTS DURING THE YEAR.

	Departed.	*Returned.*
Mr. W. E. Calton ...	—	5th June, 1933.
Dr. H. H. Storey ...	—	1st November, 1933.
Mr. R. E. Moreau ...	27th April, 1933.	13th January, 1934.
Mr. W. Nowell ...	7th May, 1933.	15th December, 1933.
Miss K. Rushworth ...	18th May, 1933.	13th January, 1934.
Dr. R. R. le G. Worsley	16th June, 1933.	24th January, 1934.
Mr. T. W. Kirkpatrick	22nd February, 1934.	—
Mr. F. M. Rogers ...	22nd March, 1934.	—

PUBLICATIONS.

The following papers contributed to scientific journals by members of the staff during the year under review have been treated as Station Memoirs and separates have been distributed :—

Observations on the Desert Locust in East Africa from July 1928 to April 1929. C. B. Williams (late Entomologist), *Annals of Applied Biology*, Vol. 20, part 3, 1933.

Pleistocene Climatic Changes and the Distribution of Life in East Africa. R. E. Moreau, *Journal of Ecology*, Vol. 21, No. 2, 1933.

On the Food of the Red-billed Oxpecker. R. E. Moreau, *Bulletin of Entomological Research*, Vol. 24, part 3, 1933.

A Chemical Survey of the Waters of Mt. Meru, Tanganyika Territory, especially with regard to their qualities for Irrigation. D. Sturdy (Tanganyika Department of Agriculture), W. E. Calton and G. Milne, *Journal of the Kenya and Uganda Natural History Society*, No. 45, 1933.

A Note on the Distribution of *Gypohierax angolensis* (Gmel.), the Vulturine Fish-eagle. R. E. Moreau, *Journal of Animal Ecology*, Vol. 2, No. 2, 1933.

Investigations of the Mechanism of the Transmission of Plant Viruses. H. H. Storey, *Proceedings of the Royal Society*, B, Vol. 113, 1933. (N.B.—This is the paper referred to on p. 5 of the 5th Annual Report under the title " Experimental Studies of the Function of Insects in the Transmission of Plant Viruses ".)

In addition to the above Memoirs a limited number of separates of the following publication have been distributed :—

Taxonomic and Field-Notes on Birds of North-east Tanganyika Territory. W. L. Sclater and R. E. Moreau, *Ibis*, Ser. 13, Vol. 2, parts 3 and 4 ; Vol. 3, parts 1, 2, 3, 1933 and 1934.

The undermentioned papers are awaiting publication or have become available since the annual distribution was made :—

Root-Systems of *Coffea arabica*, Parts I and II, F. J. Nutman, *Empire Journal of Experimental Agriculture*, Vol 1, Nos. 3 and 4, 1933.

A contribution to Tropical African Bird-Ecology, R. E. Moreau.

A Synecological Study of the Usambara Mountains, Tanganyika Territory, with particular reference to the Birds. R. E. Moreau.

The Insecticidal Properties of Some East African Plants. R. R. Worsley.

Some East African Essential Oils. R. R. Worsley.

The Distribution of the Absorbing Surface of Coffee Roots in a Volcanic Soil. F. J. Nutman.

The Ecology of Coffee Plantations. T. W. Kirkpatrick.

VISITORS.

Official visitors to the Station during the year include His Excellency Mr. D. J. Jardine, C.M.G., O.B.E., Acting Governor of Tanganyika Territory; Mr. S. B. B. McElderry, Chief Secretary, Zanzibar; Mr H. M.-M. Moore, C.M.G., Colonial Secretary, Kenya; Mr. F. Longland, Provincial Commissioner, Tanganyika; Mr. D. C. Campbell, Assistant Secretary, Tanganyika; Mr. B. D. Burtt, Survey Botanist, Tsetse Research, Tanganyika; Dr. R. R. Scott, Deputy Director of Sanitary Services, Tanganyika; Dr. D. B. Wilson, Malaria Research Officer, Tanganyika; and the following members of the Agricultural Departments of contributing territories:—Dr. J. D. Tothill, Director of Agriculture, Uganda; Mr. H. B. Waters, Director of Agriculture, Kenya; Mr. H. Wolfe, Deputy Director of Agriculture, Kenya; Mr. A. J. Findlay, Director of Agriculture, Zanzibar; Mr. T. J. Anderson, Entomologist, Kenya; Mr. J. McDonald, Senior Mycologist, Kenya; Mr. A. D. le Poer Trench, Senior Coffee Officer, Kenya; Dr. R. H. Le Pelley, Entomologist, Kenya; Mr. S. Gillett, Agricultural Officer and Experimentalist, Kenya; Dr. W. S. Martin, Agricultural Chemist, Uganda; Mr. H. Hargreaves, Entomologist, Uganda; Dr. G. B. Wallace, Mycologist, Tanganyika; Mr. W. V. Harris, Assistant Entomologist, Tanganyika; Mr. C. Harvey, District Agricultural Officer, Tanganyika; Mr. F. R. Sanders, District Agricultural Officer, Tanganyika; Mr. S. M. Gilbert, Chief Scientific Officer, Coffee Research Station, Moshi, Tanganyika; Mr. J. C. Eyre, Agricultural Officer, Tanganyika; Mr. G. H. Gethin Jones, Soil Chemist, Kenya.

Unofficial and overseas visitors were increasingly numerous, partly, no doubt, as a result of the improved road communication with the port of Tanga. They included Sir John Sandeman Allen and Mr. R. B. Harvey, Members of the Joint East African Board.

REPORT OF THE DIRECTOR.

The Director was absent on vacation leave from early May until mid-December. The direction of the Station was first assumed by Mr. T. W. Kirkpatrick, who continued to act until the beginning of November, and then by Dr. H. H. Storey on his return from leave.

Finances.

The abolition of the Empire Marketing Board, through which the Imperial contribution to the maintenance of the Station has been paid from the beginning, gave rise to some financial uncertainty during the year. For several months previous to the end of September, when the Empire Marketing Board grant terminated, and until official notification was received that the subsidy would be continued, at any rate for the time being, the Acting Director suspended all avoidable expenditure. This action produced a saving on the year's estimates, which together with the revenue from the sale of quinine, reported last year, has brought the reserve to the figure of £3,055 (see Appendix A). Permission has been received to expend part of this fund on certain needed capital items, viz., the purchase of a new lorry, the completion of the hydro-electric power-station, and the provision of a raspador for cleaning small samples of sisal leaf.

The Kwamkoro Estate in spite of a very small crop has been made to pay its way, and is still credited with a working margin which enables slow regeneration with more reliable bearing material to continue.

Co-ordination of Research.

In February, 1934, a conference—one of a series convened at the instance of the East African Governors' Conference for the co-ordination of the scientific services—was held at Amani and attended by officers of the Agricultural Departments of Uganda, Kenya, Zanzibar, and Tanganyika, including the Directors of the three first named. The subjects under discussion were Plant Protection, Entomological and Mycological research, Coffee research, and the foundation of an East African Agricultural Journal. Agreement was reached regarding the measures to be taken to secure the co-ordination of work on these subjects, and the decisions were reported to the Governors' Conference.

Central Quarantine Station.

The isolation greenhouses for the Central Plant Quarantine Station have been completed, save for certain supplementary fittings, during the year, and have been in use for some months. They consist of a reception house, with six compartments completely screened off, with entirely separate entrances but having a common ventilating system worked by electric fans, and a large

observation house in two compartments, with concrete soil tanks, to allow of full development after propagation, while isolation from contact with outside plants is still maintained. The rules which are to govern the working of the station were agreed upon at the Conference mentioned above, and are published in its report.

Local Experiment Stations.

In the First Annual Report* of the Amani Research Station the necessity was indicated for a sub-station on the Tanga plain and another "somewhere in the Moshi-Arusha area." In a form different from that which was then contemplated, and one which, given the continuation of a co-operative spirit, is more desirable, this need is now to be provided for. The Coffee Experiment Station at Lyamungu, near Moshi, is already in being, although the main buildings are still to be erected, and financial arrangements have recently been made for a sisal experiment station, for which a location is being sought between Tanga and Muhesa. If, as is highly probable, the type of organization for the sisal station follows that of Lyamungu, the constitution may be considered to approach the ideal, since it associates intimately the Department of Agriculture and the growers, and provides facilities both for agronomic investigations and for fundamental research. The wider field for experimental work will be invaluable for the purposes of the Amani Station.

External Relations.

The usual close relationship has been maintained with official institutions in England, the Royal Herbarium, Kew, the Natural History Museum, and the Imperial Agricultural Bureaux and Institutes. Special acknowledgment must be made of the services of the Imperial Institute, which in addition to exchanging views on the testing of sisal fibre, and continuing the arrangements made for standardized tests of the liquoring quality of coffee samples, has also undertaken the examination in certain respects of soil samples from the Amani collections, and so is rendering much needed assistance to a section faced with a task of impossible dimensions. The services of Messrs. J. Gilliat and Company, in making the long series of liquoring tests above referred to, are also gratefully acknowledged.

With the approval of the Secretary of State for the Colonies, facilities were given for a German post-graduate student of agriculture, Dr. E. H. Schwenke, to reside and work at the Station for a period of six months.

Progress Reports.

There is not much that can be usefully added to the review of the work in hand at Amani given in last year's report. A year is a brief period in the progress of long-range research, especially

* Non-Parliamentary publication, Colonial No. 50, 1930.

when results wait upon the maturing of plants as slow to develop as coffee and sisal. The sectional reports will show that work has proceeded steadily and without interruption, save where leave has intervened, through the year. They also show, what is evident to the observer on the spot, the extent to which increasing experience is leading officers to greater confidence and facility in handling the material of their studies. The one thing to be feared at this stage is a break in continuity.

Coffee Investigations.

A well-prepared scheme to confirm the theories which have been formed regarding over-bearing and dieback in coffee, involving the residence for the critical period of the Plant Physiologist in the Arusha area, was defeated by the persistence, in this particular year, of the selected trees in carrying a heavy crop to maturity in defiance of confident expectations. Anticipatory work on the root systems turned perforce into an investigation of the total absorbing area of the root system of healthy trees. The laborious measurement of feeding roots occupied a team of African youths for many weeks, and the data obtained are probably unique. Experimental evidence regarding the inhibition of root growth by acidity, the field evidence of which has already been published, is being sought in a series of water cultures.

The evidence supplied by the Entomologist's investigations on the intimate climatic factors in coffee plantations, now awaiting publication, differs in so many respects from normal anticipation as to provide immediate justification for undertaking the research.

The results so far received from London of the liquoring tests of a wide range of samples are highly confusing and throw no perceptible light on the questions involved. Correlation with the prices obtained, where these are known, is very far from exact and in many cases appears to be non-existent, while regional reputations are not consistently confirmed. Yet the high premiums paid for certain coffees, in some cases having no previously established reputation, seem to show that there is, however fallible it may be, a sincere recognition of quality, demonstrated in hard cash.

The investigation of methods of budding and grafting at varying ages has led to the conclusion, which does not seem likely to be disturbed, that the inarching of one year old nursery plants gives most readily the results required. The method calls for no great skill and no special equipment and is capable of yielding 100 per cent. of successes. Topworking by a similar method seems also likely to be preferred.

The visible results of heavy applications of organic manure to *arabica* plots at Amani, even when the trees were old and moribund, confirm the conclusion previously drawn from comparison with Kiambu, that this measure effectively offsets the influence of soil acidity.

A number of coffee selections made by the Geneticist have already been sent for trial to the Coffee Station at Lyamungu, and others, for comparison, to the Scott Laboratories at Nairobi.

Sisal and other Agaves.

At the outset of his leave the Director spent about ten days at the famous garden of La Mortola, on the Italian Riviera, to decide certain questions of nomenclature and to choose, from a collection unrivalled in Europe, species of Agave which might be useful in themselves or for hybridization. The selection sent to Amani is elsewhere recorded. Thanks are due to Mr. Cecil Hanbury, M.P., for the generous way in which facilities were given and to Mr. S. McL. Braggins, the Curator, for enthusiastic assistance and many personal services.

Several uncut plants of *Agave amaniensis* at Amani have poled during the year, and each has produced a number of capsules which it is expected will contain a small proportion of viable seed. Hitherto no seed-bearing plant of a commercial type has been available here, seed of sisal having to be obtained from the Kenya Highlands. This event opens up possibilities of hybridization more promising than the previous use of *A. angustifolia*. A cross between *A. amaniensis* and *A. cantala* is particularly inviting in view of the especial fineness of *cantala* fibre. The prospective seedlings of *A. amaniensis* itself are awaited with great interest. The propagation of *amaniensis* from suckers, with the immediate aim of providing a quantity of fibre sufficient for a commercial test, goes forward at an increasing rate.

The comparative testing of fibre has now been standardized on what seems a fairly satisfactory basis, and the method of photographing microtomed cross-sections of leaves makes fibre counts easy and reliable. Further progress awaits the provision of suitable means of decorticating single leaf samples. The Station is indebted to Colonel the Hon. M. T. Boscawen, of Moa Estate, for the much appreciated gift of a Cormorant decorticator, which we are not however in a position to use to advantage pending the acquisition of a more powerful engine than we at present possess.

The first lot of sisal seedlings raised at Amani are now becoming ready for fibre tests. A further 10,000 seedlings have been raised during the year from seed kindly supplied from Longonot. The first plot of *amaniensis*, at Sigi, is ready for the cutting of a year's production of leaf.

Expansion of the work on sisal and related fibres awaits the establishment of the low-level station.

Soil Investigations.

The imminence of the International Congress of Soil Science to be held at Oxford in 1935 makes desirable the preparation of a map for presentation to the Congress representing the current state of knowledge of East African soils. The degree to which this is

possible is discussed in the Soil Chemist's report. Mainly with the object of furthering this project and by this means correlating the results of local investigations, a conference of soil chemists is to be held in Zanzibar in August, 1934.

In the Soil Chemist's report an interesting and thoughtful account is given of his safari through the Southern Highlands of Tanganyika. It is only now, as the result of scientific study to which the Amani Soil Laboratory has made its contribution, that one can even begin to express an opinion on soil questions with any confidence that it is soundly based. The travelling land commission, which the Tanganyika Government with unusual administrative foresight sent round a few years ago to explore its unoccupied lands, was obviously seriously limited in its usefulness by the absence of a reliable body of data correlating possible crops with soil and climate.

Leaving aside the political motives which influenced colonization in Iringa, the truth is that your pioneer is intolerant of restraint or cautionary delay. He has the sporting rather than the business instinct and prefers to gamble for his chance of success. Science may later have its say, though in our present unregulated state the foundation of a profitable farm or plantation is more usually the sunken capital of previous owners.

W. NOWELL,
Director.

REPORT OF THE PLANT PATHOLOGIST.

Virus Diseases of Plants.

(a) *The mechanism of the transmission of Plant Viruses by insects.*

The basis of this line of work, which continues to be the main subject of my investigations, has already been indicated in previous reports. By an intensive study of the transmission of the virus of maize streak disease by *Cicadulina mbila* and *C. zeae*, I aim at a clearer understanding of the details of this process. There can be little doubt that the results will be applicable to a large number of plant viruses, although certainly not to all. In spite of my absence from Amani on leave half the year, I am able to report considerable progress.

The first results from the development of a method of the inoculation of the virus into insects were summarized in my last report. A full account of this work has since appeared in the Proceedings of the Royal Society. I had then reached the stage of showing that in the vector-insect the virus, ingested by mouth with the food taken up from a diseased plant, passed after a short time from the intestine into the insect's blood. I also showed that the

difference in the behaviour of " inactive " races of the vector-species lay in a failure of this passage of the virus from the intestine into the blood.

The next step was to trace the movement of the virus to an organ of the insect's body, whence it would come to be inoculated into a healthy plant upon which the insect might feed. It has generally been held, and can hardly be doubted, that this organ is the salivary gland. Attempts to prove this point gave unexpected results, the interpretation of which is still not clear.

In consequence I have felt it necessary to deviate from that line of study temporarily, in order to obtain a clearer understanding of the details of the process of normal infection of the plant by the insect. This work is now in progress. It has afforded surprising results of which the interpretation is at present uncertain. I am attempting by histological studies of the punctured leaf to explain the results obtained by experiment.

It has frequently been maintained that, because insects may remain infective for long periods without receiving any additional supply of virus, a multiplication of the virus must occur in the insect's body. At the time of writing my last report, I was inclined to accept this view. Recent results however admit of an alternative explanation and at present I regard the question as an open one. I have no clear-cut evidence either way, and it is difficult to see how such evidence may be obtained.

A line of work has been undertaken as a consequence of the proof by Perdrau and Todd (Proc. R. S., B. Vol. 112, pp. 277 and 288) that certain animal viruses, as well as certain strains of bacteriophage, are inactivated in vitro by the combined action of Methylene Blue and light. It was hoped that, if the streak virus proved to be susceptible, a technique might be forthcoming for providing evidence upon the movement of the virus in the insect. This hope appears unlikely to be realized. It is however of some interest that the virus of a plant disease is susceptible to the same inactivating influence as animal viruses and the bacteriophage. My experiments have been consistent in indicating a complete inactivation of the streak virus by the addition of Methylene Blue in concentrations of 1 in 10,000 and 1 in 100,000 and exposure to diffuse daylight.

Recent results in the feeding of pure active races of *Cicadulina zeae* afford the hope that the difficulties, that have hitherto prevented my bringing this work to a successful conclusion, may be overcome. As I have previously reported, inactive races may be readily raised. The basis of their inactivity appears to rest upon the same physiological character as the inactivity of races of *C. mbila*. It is important however to ascertain the manner of inheritance of the factor for activity in *C. zeae*, in order that a comparison may be made with that in *C. mbila*. This work must

await the establishment of pure active lines of *C. zeae*, and I hope that it will be brought to conclusion during the forthcoming year.

Work has been begun upon the sampling of the *Cicadulina* populations of different localities. Already the evidence suggests that the proportions of active to inactive individuals may show wide differences in different localities. If this suggestion be definitely proved, it will open up a line of investigation of some fundamental interest and conceivably of practical importance.

During my leave I worked for a month at the Molteno Institute of Parasitology, Cambridge, upon the histology of *Cicadulina mbila*. The object of this work was twofold : to discover (1) whether any anatomical difference existed between active and inactive individuals of this species, and (2) whether the virus produced any visible effect in active insects. Time did not permit of the completion of this work, which will be continued at Amani. I make acknowledgement to Prof. Keilin, F.R.S., both for affording me the facilities for work at the Molteno Institute, and for his interest in this and other features of my investigations.

Papers upon my recent studies were read to the Third International Congress for Experimental Cytology, at Cambridge, and to a Conference of Virus Workers at Rothamsted.

(b) *The Mosaic, or Leaf-curl, of Cassava.*

The extension of equipment, provided by a grant from the Colonial Development Fund, has already borne fruit in the proof that a species of white-fly (*Aleurodidae*) can transmit the mosaic disease of Cassava. This insect has long been under suspicion as the vector, and Ghesquière (see Kufferath and Ghesquière, C.R. Soc. Biol. Belge CIX, p. 1146) has attributed transmission in the Belgian Congo to a white-fly, without however offering any evidence in support. An experiment carried out by Mr. Nichols during my absence on leave, in which several thousand white-fly were liberated in a chamber of the greenhouse containing healthy and diseased cassava plants, resulted in the rapid infection of all the healthy plants. Repeated experiments, in which similar white-fly were confined on single leaves of cassava plants, all failed. These contradictory results cannot be explained at present ; but it is clear, as I have long recognised, that the single-leaf cage method is an unreliable tool in the search for the vector of a new disease. It may be noted that I encountered similar difficulties in transmission experiments with the leaf-curl of tobacco.

This positive result has been followed up by similar experiments, using however lines of white-fly reared from single females and observing extreme precautions to avoid the accidental introduction of other insects into the greenhouse chambers. These experiments serve two purposes : (1) the confirmation of the earlier result,

which, owing to the conditions of the experiment, might conceivably have been due to another species of insect accidentally introduced, and (2) the provision of pure line material of the vector species. This material will be submitted to a specialist for determination, as far as is possible with this difficult group. As, at the time of writing, the disease is beginning to appear in the second series of experiments, the part played by white-fly in the transmission of Cassava mosaic appears to be satisfactorily proved.

Certain field experiments have been carried out with this disease. They have demonstrated in a striking manner the severity of its ill-effects, the crop from diseased plants being almost nothing. An experiment of somewhat elaborate layout, recently started, aims at the determination of the age of the plants at which their susceptibility is at its maximum, and the season of greatest infection.

Of considerable practical importance to native agriculture in East Africa is the search for varieties of cassava resistant to mosaic. Work on these lines is understood to be in progress in several Departments of Agriculture. I have collected at Amani a number of varieties from local cultivations and elsewhere, including six varieties received from the Director of Agriculture, Uganda, originally imported from the West Indies, and two from West Africa, supplied by Mr. H. A. Dade of the Gold Coast. The two latter are reputed to show a high resistance in their country of origin and have remained healthy in the Amani plots. Grafting experiments have however shown all the varieties now available without exception to be susceptible to the disease. The method of grafting, although valuable for quickly demonstrating complete immunity, gives no evidence upon the relative susceptibility of varieties. It is clear that the only reliable guide to probable performance in the field is the evidence of plot trials in a locality where the disease naturally spreads freely. Consequently any contribution by Amani to advance on these lines must await the provision of suitable land on the plains.

(c) *Tobacco Leaf-curl.*

The attempt, to which reference was made in my last report, to breed lines of tobacco varieties resistant to this disease has ended in failure. During the past season every plant of the selected strains has succumbed to the disease, except only in the variety Sterling. Here, however, there is no difference in the behaviour of lines, selected as resistant and susceptible respectively. The better performance of Sterling is doubtless to be attributed to a slightly higher resistance characteristic of this variety, which has been evident in previous years' trials.

Studies of the transmission of this disease have been discontinued for the present. Confirmation of the ability of a species of

white fly to transfer the virus, already reported from Southern Rhodesia and Nyasaland, has now come from South Africa (A. P. D. McClean, *in litt.*).

General.

My assistant, Mr. R. F. W. Nichols, has continued to take an important part in all experimental work.

H. H. STOREY,
Plant Pathologist.

REPORT OF THE ENTOMOLOGIST.

I returned from Kenya at the beginnng of April, 1933. Owing to the absence on leave of the Director and the Plant Pathologist, I was in acting charge of the Station from May till November. As the Secretary and Librarian and the Stenographer were also away during this period, but little opportunity presented itself for fresh investigational work on the Eco-climates of coffee plantations.

Moreover, all the available time was required for digesting the information accumulated during the previous year, and preparing a paper for publication. The first three parts of this, which it is hoped will be the forerunners of further communications on the ecology of coffee plantations, have now been completed. Part I consists of a short introduction to the subject of weather and climate in relation to insect pests of agriculture, and an account of the "standard" climate of the district—Kiambu—where the investigations were undertaken.

Part II describes the climatic conditions which were found to occur in a fully-grown close-spaced coffee plantation, on level ground, without shade and unprotected by a windbreak. Records of temperature and humidity are given, both between the rows and within the bushes, and at different heights above the ground. Information is also given on the temperature of the soil at one, five, and fifteen centimetres, and on the temperature of the trunk and leaves of a coffee bush. The penetration of wind into the plantation and of light into the bush is described, also the varying rates of evaporation in different situations. The amount of rain reaching the ground under a bush and under the drip of the branches is discussed.

So far as possible all the records are compared with those of the standard meteorological station erected on open ground nearby.

Part III is an account of the influence on the climatic conditions in a coffee plantation of various modifying factors, viz., the slope of the ground, spacing of the bushes, pruning, shade, windbreaks, cover crops, and mulches.

It may be said that although during any given type of weather, and in any particular locality in a coffee plantation, the meteorological conditions may be widely different from those recorded at a

standard station, there is a distinct relation between them. It follows that although it may be very misleading to base deductions as to the behaviour and activities of insects on a knowledge of the standard climate alone, yet such knowledge should enable one with a little experience to deduce the actual conditions to which an insect in a particular locality is subjected.

T. W. KIRKPATRICK,
Entomologist.

REPORT OF THE SOIL CHEMIST.

General Survey and Classification.

In previous annual reports the growth of the Amani collections of material contributory to an East African Soil Survey has been recorded. This year the further additions have been substantial, serving both to fill in detail for districts already studied in first outline, and to provide the first outline for districts new to the survey. Hitherto (except during my introductory journeys in Kenya and Uganda in 1928) my own work in soil reconnaissance has been confined to Tanganyika, but in September, 1933, I was able to spend a fortnight, partly on such work, in Zanzibar; this is reported on further below. All the material so collected is, of course, fragmentary, in the sense that there has been no systematic area-survey from which the boundaries and extent of soil types could be determined. The possibility of organizing such a two-dimensional survey is not in sight yet. For the present purposes of reconnaissance, observations at scattered single points must suffice, supplemented by qualitative notes made along the routes of journeys and accounts of general soil conditions contributed by observers familiar with particular districts. An observation of detail is considered of good value if it consists of notes and samples of a carefully-observed profile whose circumstances of occurrence are sufficiently described to enable its properties, when worked out in the laboratory, to be connected up with the factors of soil-formation ruling in its locality. A district then becomes "mappable" in a rough way when even a very few such observations have been made, provided that they represent soil conditions in all the chief physiographic divisions of the countryside in question, and that there is enough replication to show that the occurrences noted are typical. It will be of interest to list, for Tanganyika, the districts which I now consider mappable in this sense from data in my files —at least as far as the field notes and samples are concerned. As will be mentioned below, the necessary laboratory work on some of this material is still in arrears. The list follows, in two parts:—

I. Areas mappable with some knowledge of the actual extent of the different soil types:—

The two Usambara massifs, East and West, and their southern and western foothills.

Kilimanjaro and a radius of 40 miles from its peak except to the north-east.

Meru and Mondul and a radius of 20 miles.

Rungwe and a radius of 20 miles, with extensions south to the Lake Nyasa coast and north to Mbeya.

A district of some 20 miles radius centring on Mbosi, near the Northern Rhodesia border.

A portion of the coast plain near Tanga.

(In this part of the list can probably also be included the districts surveyed before the war by Dr. P. Vageler, namely, the Mkatta Plain between Morogoro and Kilosa, the Wembere sunkland in the Tabora Province, and parts of Ugogo.)

II. Areas mappable without actual knowledge of the extent of the soil types, but with the relation between soil type and general physiography approximately known :—

The coast belt at a few points (Bagamoyo, Dar es Salaam, the Rufiji delta, Lindi, Kilwa) but not continuously).

The Paré Mountains and the Paré—Usambara gap.

Handeni, Kondoa Irangi, the settled area about Mbulu.

The Lake Victoria coast and islands near Mwanza and near Bukoba, and the highlands between Bukoba and Kigoma.

The Iringa plateau and the forested fringes along its eastern and south-eastern scarps (Dabaga, Mufindi, Lupembe).

The Ubena (Njombe) grasslands.

The Uluguru Mountains and foothills.

A small area in the Central Province near Kazi-Kazi.

There are also isolated observations of good value from points in Songea, Ufipa (Sumbawanga), and northern Ugogo Mpwapwa). Finally there are the soil notes made by Mr. A. M. Telford in his Report on the Development of the Rufiji and Kilombero Valleys (1929), by Mr. C. Gillman on railway surveys, by Messrs. H. Wolfe and W. J. Hill during the Land Development Survey, 1929, and by geologists along the route of the once-projected Dodoma—Fife railway.

The above lists do not convey their full significance unless a third is added :—

III. Areas not mappable from any direct information such as would enable their soils to be classified or described in relation to known types :—

Almost the whole of the central plateau lying between 3° and 8° S. latitude and between 31° and 36° E. longitude.

A great part of the coast belt; the Lake Tanganyika coast; the whole of the Lindi Province except at the

coast; Mahenge; the greater part of the Eastern Province; the Lake Rukwa trough and southern Usangu; the Serengeti Plain, the Masai Steppe.

List III thus comprises by far the greater part of the total area of the country, and includes some the most-discussed areas of potential or actual native export-production, the Shinyanga area where the most pressing administrative problem is that of soil erosion due to cattle, the great game plains, the Masai grazing-grounds, and the potentially-habitable country of the tsetse belts. For these areas my files are virtually empty.

The state of knowledge is, I understand, generally similar in the other East African territories for whose soil surveys Amani is the co-ordinating centre. That is to say, a few districts (chiefly those of intensive white settlement, except in Uganda) are becoming known fairly intimately, and scattered observations are available over parts of the rest, but the largest total area in every case is, through lack of direct technical information, "unmappable" except by risky deductive methods. Nevertheless, it has been agreed this year to proceed to the preparation of a draft soil map of East Africa on a scale of 1 in 2,000,000, with a view (*a*) to publishing for general use the information that is available and (*b*) to calling attention to the large gaps that exist in recorded soil knowledge in order that interest (possibly even financial interest) may be stimulated in the matter of filling them.

Correspondence to this end with those responsible for soil work in each territory has been carried on as opportunity offered since the meeting of East African soil chemists which was held at Amani in 1932, and whose findings, published elsewhere, were summarized in my last annual report. A further meeting has now been arranged, to be held in Zanzibar in August, 1934. It is hoped that Nyasaland, and possibly Southern Rhodesia, will participate at this meeting, though Northern Rhodesia will, for financial reasons, again not be represented, except by written communications from the officer (Mr. C. G. Trapnell) who is conducting an ecological survey there.

In my report* for 1931-32 (p. 16) it was noted that the limits of reconnnaissance survey in the sense discussed above appeared to be set not so much by the amount of voluntary assistance that could be enlisted from workers engaged on other duties in the field, nor by the quality of the records so gathered, but by the amount of laboratory time required to extract the technical information from the material collected. In the following year this check to the development of the work began to be noticeable, as my inability to describe their soils to them adequately and with reasonable promptness on a basis of laboratory examination, and further the impossibility of my travelling sufficiently to make touch with the soils for myself in their districts, led some contributors very

* Non-Parliamentary publication, Colonial No. 78, 1932.

naturally to cease their collections. I am the more grateful to those who, in spite of this, have continued; but the circumstance was discouraging, as I had been at pains since 1929 to build up a body of good will and interest in soil-reconnaissance, particularly in Tanganyika where there was no Agricultural Chemist to undertake the service. In the year under review, however (for the first time a full year for myself and my assistant together), analytical work has approximately kept pace with new accessions of material; also there has been a full year's operation of the scheme whereby the Imperial Institute is undertaking in London the analysis of clay fractions sent from Amani; and the Soil Chemist appointed to the Coffee Research Station now being developed on Kilimanjaro has been quartered here since his appointment in October, 1933, and has materially assisted in overtaking arrears of work on soil samples from the coffee districts. As a result of the year's work, therefore, the volume of analytical results available and their bearing on essential points of soil description have begun to be enough to justify publication, and this will be proceeded with during the coming year.

My travelling for the year has consisted in a journey in the Iringa Province in company with the Botanist, and a visit to Zanzibar and Pemba.

The main purpose of the Iringa Province journey was to visit the volcanic area around Rungwe Mountain at the head of Lake Nyasa. Soil collections and notes of exceptional interest had previously been received from the agricultural officers there. This district supports, at the expense of progressive deforestation, a dense native population practising a fairly advanced form of agriculture, and, under a rainfall approaching 100 inches, it has always been regarded as a "granary". It now, for instance, supplies stocks of native-grown foodstuffs, including wheat and rice, to the Lupa goldfield, and there is a small native *arabica* coffee industry of growing prosperity. Yet European enterprises there have not prospered. Coffee planting was started on a considerable scale in 1926-27, but after an early promise of large harvests most of the plantings had been completely abandoned by 1931, and the remainder are being kept going by a heroic and quite uneconomic perseverance. Tea, which took the place of coffee in the plans for the development of the district, is by no means being established easily as a trouble-free crop in spite of apparently favourable conditions of rainfall, depth of soil, and soil acidity. Even reafforestation suffers setbacks through the mortality of trees apparently in full vigour.

The technical problem thus set by the area as a whole will require an analysis of all the factors involved in the two systems of agriculture, the native's, which to the limit of its modest aims succeeds, and the European's, more ambitious, which does not. Comparison is naturally invited between the Rungwe complex of volcanic soils and the Kilimanjaro and Meru complexes, on which nothing like the same discouragement presents itself to the planter. Certain

of the Rungwe profiles show discontinuities due to the presence of unweathered layers of pumice at variable (small) depths below the surface, and on such soils crops are clearly at a disadvantage, unless the shallow top soils can be built up and maintained as a habitat for the plant practically independent of the subsoil. This is possibly achieved by the native growing annual crops on high raised beds, or planting coffee as an afterthought in long-established banana-groves which for years have received all the cow-dung of the village; but not by the European, whose permanent crop ought to be deep-rooted, who divorces his management of it from cattle-husbandry, or who plants coffee and bananas simultaneously on a hundred acres of land previously under maize. There are, however, considerable areas on the estates well to the south of Rungwe Mountain and beyond the pumice region, where the soils, founded on trachyte, phonolite, basalt, and similar lavas, are red-brown deep loams not very different in type from those formed from kindred rocks on Kilimanjaro, and not obviously more unsuited than they to ordinary plantation-agriculture. It is true that under the high rainfall the Rungwe loams are moderately advanced in laterization (silica/sesquioxide ratios 1·5 to 1·1), but so are the Kilimanjaro loams in the high-rainfall zone (ratios 1·6 to 1·2). They are of low phosphate-status, but so are the famous coffee soils (also on lavas of the same group) of Kiambu in Kenya. Their profile is acid, but similar soil-acidity elsewhere is not associated with the same type of failure of coffee. Soil characters and origins do not yet, in fact, promise fully to explain the matter, though the conjunction of the three unfavourable properties above-mentioned is no doubt a misfortune for the district, as it is for some other East African plantation districts. A possible clue to the problem may be found in the paradox that strikes all observers in the area, namely, that the vegetation at the level of the estates in question is a characteristic example of *dry-forest*, not a *rain-forest*, in spite of the high recorded rainfall and the prevalence of mists. A closer study of the rainfall-distribution than is afforded merely by monthly totals might, I think, show that the precipitation is relatively inefficient agriculturally, whilst being, in these very deep porous loams, all too effective in its leaching action. A further factor that enters is the mischance of the prevalence in the district of a particularly noxious weed-grass (*Imperata cylindrica* var. *Thunbergii*, Dur. & Schinz.) which quickly invades tilled ground and assists in exhausting available soil moisture.

Other coffee areas visited during this journey were those around Mbosi and Itaka near the Rhodesian border, on gneiss or more basic crystalline rocks and in typical dry-forest (*miombo*) country, where also the main problem is the conservation of soil moisture through a severe dry season, but where soil properties are in other respects more favourable; that lying along the south-west flank of the Mbeya Range above (Old) Utengule, where screes of mica-schist mix with volcanic dust from the Poroto craters to form a somewhat

unusual soil carrying a dry type of acacia thorn-bush; a small irrigated planting in river alluvium by the Chimala River, under the shade of large *Acacia albida* trees left from the clearing of riparian forest; and the Lupembe-Mufindi-Dabaga farms on very poor granite soils along the edge of the Iringa plateau, where the protection of reluctant bushes from bitter winds is the patient coffee grower's chief preoccupation. The soil profiles studied, no less than the diversity of conditions under which they have developed, illustrate very well the tolerant constitution of the coffee-bush, and the wide range of problem-solutions that the agricultural adviser must be prepared to work out if he is to help the planter to convert mere tolerance into a paying exuberance.

The days spent upon coffee estates were, of course, only incidental to the general study of soil conditions undertaken on this journey, and other crops on which the visiting soil expert was expected to have, within his province, advice to offer were tobacco (Iringa), tea (Mufindi and Tukuyu), wheat and rye (Dabaga and West Mufindi), almonds and other fruit (Dabaga and West Mufindi). In native hands rice (Lake Nyasa coast), wheat (Poroto Mountains), and cotton (Uluguru Mountains) were met with. A general impression that I gained on the European farms was that means ought more generally to be devised, even where cattle-husbandry must be ruled out, of associating with the cash crop the principles of fertility-conservation that belong to the idea of " mixed farming ". It is not sufficient to clear x acres and plant them with coffee or tea: y acres ought also to be cleared and devoted in one way or another to the manufacture of organic manure. I should particularly advocate this principle for the Iringa granite soils and Mbosi. Some detailed proposals for carrying it out have been submitted, through the Agricultural Department, for the Dabaga and Mufindi districts.

While in the Njombe district I visited the Veterinary Department's experimental stock farm at Msima River, in the Ubena grasslands. The most striking feature of the soils in these grasslands is their red (subsurface) colour, which contrasts markedly with the mustard-yellow under *miombo* to the west and north on the same plateau and with the greyish-form under vestigal rain-forest along the crest of its eastern scarp. All three soils are on substantially the same parent-material (granite), and have several fundamental points of resemblance; in particular their clay-fractions group together in composition, with silica/sesquioxide ratios near 1·0 and similar contents of iron oxide. In working out the genetics of these granite soils their common feature (the advanced development of a sesquioxidic clay) may have to be accounted for as having been acquired under the regime of a past (probably both wetter and warmer) climate; and their differences as having been imposed more recently under their respective phases of the present-day climate and vegetation. The red colour of the

Ubena soils, whose overhead climate is fairly humid, may reflect the greater desiccating effect of a grass vegetation when compared with either forest or *miombo* (open *Berlinia* woodland), which latter is characteristically a type adapted to a moderately low and unevenly distributed rainfall.

A note on soil conditions at Msima River was communicated to the Director of Veterinary Services. The various enterprises in stock-husbandry (bacon, dairy-produce, wool) upon which expectations of prosperity for the Iringa uplands were placed a few years ago are nearly all now abandoned, and it seems probable that a root cause of this disappointment may lie in the advanced state of weathering of the granite soils, though the immediate causes of mortality or unthriftiness in stock have been assignable in quite other directions, as to infestation by parasites and the like.

In September, 1933, I visited Zanzibar and Pemba at the request of the Director of Agriculture, for the purpose of discussing with the Government Chemist (Mr. L. W. Raymond) a programme of soil investigations, particularly with reference to the clove industry, which had been drawn up. This visit has been the subject of a separate report, one section of which, a " Sketch of Soil Conditions in Zanzibar and Pemba ", was an attempt, on an admittedly slender basis of fundamental information, to classify the soils, explain their genesis from the sedimentary rocks that are their parent-materials, and point out from this standpoint some directions which further soil investigations directed to practical ends might take. The work on Zanzibar soils is being continued in both laboratories. I have to acknowledge advice on the geological side in this Zanzibar work from Mr. G. M. Stockley of the Tanganyika Geological Survey.

The permanent exhibit of soil profiles, mentioned in last year's report, is now housed conveniently in cabinets, and the number of profiles set up for display and convenient comparative study is about 70.

Special Studies of the Soil Groups.

Work under this head is not readily separable from that reported on above, for the accessions of material brought in as the survey proceeds are the stock of data from which general views of the principal soil groups are gradually obtained. It has been of particular interest during the year to note that certain " red earths " occurring on gneiss or granite near scarp-edges at altitudes of the order of 6,000 feet above sea-level (latitudes 3° to 8° S.) where the precipitation is high, the temperatures relatively low with occasional frost, and the vegetation rain-forest, show features linking them to the podsols of north temperate latitudes; namely, an accumulation of humus extremely poor in bases at the surface and the occurrence of a pale-coloured horizon below it. Other essential features of the true podsol are however absent, in part no

doubt because the current podsolising process is operating on a clay already pretty far advanced in laterization (silica/sesquioxide ratios less then 1), but also because the conditions are not far enough removed, by altitude, from those defined by their latitude. Material which I now have available from levels ranging up to 12,300 feet on Kilimanjaro (collected by Mr. P. J. Greenway, January, 1934) may throw further light on the occurrence of true low-latitude podsols, though on Kilimanjaro we have to do with relatively young soils and the characteristic podsol morphology is not yet developed, at least not visibly to the eye. The ideal field of work on this interesting theoretical point would be on Ruwenzori (Uganda), where ancient crystalline rocks occur at great altitude and under incessant rain.

A further matter of current interest in regard to the morphology of " red earths " is that I cannot find support either from field observations or from clay-analyses for the theories, current particularly in German texts on tropical soils, that laterization proceeds under an intermittently moist, or " periodic ", climate rather than under a steadily moist, or " humid " one, and that the process includes a counter-leaching of sesquioxides towards the surface during the dry season, resulting in crust-formation at the surface. On the contrary, the more advanced examples of laterization, i.e., the least siliceous clays, appear to be formed under rain-forest; and the examples of surface crust that I have encountered are satisfactorily explained as " murram " or " fringing ironstone " formed originally, in a previous cycle of soil formation, as a subsoil horizon at a level of fluctuating water-table towards the foot of a long slope, and subsequently exposed by tectonic movements and erosion and hardened by exposure. The " laterite crust " does not, I think, merit status as a surface-horizon of a complete soil profile.

A complex or " catena " of associated soils that has been brought under preliminary investigation this year is that carrying a distinctive dry type of deciduous thicket (" Itigi thicket ") in parts of the Central Province, Tanganyika. They are granite-derived soils, but the typical phase is found not on the granite itself, nor on ordinary transported detritus, but on a cemented crust of granitic residues that overlies the granite as a sheet continuous over large areas. The crust (" grey cement ") is siliceous, and is assigned by geologists to an age earlier than the earth-movements which formed the Rift Valleys. The most immediately striking property of the soils on it is their high acidity, though the region is one of low rainfall and hot conditions, and the zonal soil type might have been expected to be unleached. A tentative essay on the genetics of these soils has been drafted and discussed with the collector of this material (Mr. B. D. Burtt, Survey Botanist, Tsetse Research Department), and further work is projected when I shall have been able to visit the area personally.

Erosion.

The journey to the Iringa Province above-reported took me through several areas of accelerated erosion, namely, in Ugogo, at Tosamaganga near Iringa, at Malangali, and in the foothills forming the south-eastern limit of the Usangu plain. I have thus been able to add a little to my laboratory material bearing on erodibility as a property of soil, but I am still not proceeding systematically with work on this subject, as no specific survey of the eroded or potentially erodible districts is at present under consideration.

Manuring.

The following note by Mr. L. R. Doughty, Geneticist, refers to the field experiment on the manuring of *arabica* coffee which has been dealt with under this section in previous annual reports :—

Adoption of the amendments outlined in the last annual report, namely, the elimination from the observations of all border plants, and the recording of yields for each individual tree, has served to demonstrate rather more forcibly than was expected the very variable nature of the trees in respect of yield.

The frequency distribution of yield per tree shows a very marked preponderance of trees giving very poor and negligible yields, while the trees giving moderately high yields are few and scattered over a wide yield-range. Variability in tree number per plot has been increased considerably by the new layout. It is thus obvious that the arithmetic mean of the yield of individual trees on any given plot is a very unsatisfactory figure and yet this has perforce to be used in making comparisons of the response of plots under the various treatments.

The combination of the above variables makes analysis extremely difficult and the data obtained very unreliable; the information obtained is not commensurate with the amount of work involved.

Yield figures for the three years 1931, 1932, and 1933 have been considered from all aspects, and the unsuitability of the material for the purposes in view (4th Annual Report*) is no longer in doubt. The experiment has therefore been discontinued, although much of the experience gained will prove of value in any future work of a like nature. The outstanding lesson is the necessity of conducting a uniformity trial on the material for an extended period before the application of any differential treatments.

Miscellaneous.

Mr. H. B. Stent, Soil Chemist to the Tanganyika Department of Agriculture's Coffee Research Station at Lyamungu, Moshi, has worked in the soils laboratory at Amani since October, 1933, pending the erection of the new Research Station's buildings.

In July, 1933, I visited the headquarter station of the Agricultural Department, Tanganyika (at Morogoro), and that of the

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* Non-Parliamentary publication, Colonial No. 78, 1932.

Geological Survey (at Dodoma); and in September that of the Department of Veterinary Services and Animal Husbandry (at Mpwapwa) where I saw the experimental work in the measurement of run-off and erosion on grazing land that Mr. R. R. Staples (Pasture Research Officer) is undertaking.

Mr. G. H. Gethin Jones, Soil Chemist, Kenya, visited the laboratory for some days in May, 1933, and Dr. W. S. Martin, Agricultural Chemist, Uganda, and his assistant Dr. G. Griffith, have both paid similar visits during the year, in February, 1934, and April, 1933, respectively.

In March-April, 1933, assistance was rendered to the Department of Sanitary Services, Dar-es-Salaam, in matters concerning the pollution of streams by sisal-waste, by the analysis of a series of samples of river-waters.

G. MILNE,
Soil Chemist.

REPORT OF THE BIOCHEMIST.

During the period under review I have been absent on vacation leave for eight months out of the twelve and in consequence there is little progress to report. The first two months, prior to going on leave, were occupied in finishing off work, described in last year's report, on insecticides and essential oils.

Insecticides from Local Plants.

No further results have been obtained since the last report, but a paper has been submitted, and should be in print before this report is published, on the results previously reported. Work is continuing on this subject.

Fermentation and Preparation of Coffee.

This subject is being investigated in some detail and many preliminary trials are now in progress. It is almost certain that fermentation is a quite unnecessary process as far as quality is concerned and is only a method, and a rather primitive one at that, of cleaning the beans.

The effect of temperature during drying is a more difficult problem, and a series of small-scale experiments on different temperatures and methods of drying is now in progress.

One of the great difficulties met with in work of this kind is the correlation of the quality of the finished coffee with the conditions under which it is prepared; but it is hoped to overcome this, as far as possible, by submitting the samples through the Imperial Institute for the expert estimation now standardized in the series of samples being supplied from various parts of East Africa.

Essential Oils.

Work is continuing on these oils and a paper on the subject will be published in the Bulletin of the Imperial Institute.

The prices of nearly all oils have been very low since the depression but there are now signs of improvements, and it is hoped that some of those examined will prove of commercial value in East Africa.

Acidity and Root Growth in Coffea Arabica.

Experiments have been started by the Physiologist and myself on this subject and are referred to in the former's report for the year. When the Physiologist goes on leave shortly I shall take over his work in this investigation.

Other Work.

The electric micro-combustion furnace designed by myself and the Physiologist for the estimation of carbon in plant tissue is finding general use in many ways. The Soil Chemist has adopted it for the determination of carbon in soils, and one has also been purchased by the Soil Chemist in Uganda. It is expected that other soil chemists in East Africa will also order this furnace.

I have found it very useful and rapid for ordinary chemical combustions of organic compounds, a few small modifications making it suitable for determining hydrogen as well as carbon. It is hoped to publish a short paper to illustrate its general usefulness in the near future.

R. R. WORSLEY,
Biochemist.

REPORT OF THE PLANT PHYSIOLOGIST.

Coffee Investigations.

1. *Root Studies.*

Acidity and Root Growth.—Although field information on this problem is collected when available, experimental evidence is necessary, more especially since it appears probable that other factors may modify the effects of acidity. In collaboration with the Biochemist a series of cultures has been set up in order to study the relationship between the reaction of the medium, its concentration and root growth of coffee in it. Full results are not yet available, but the evidence so far obtained tends to confirm the conclusions drawn from field studies. At moderate concentrations maximum root growth is being made in solutions approaching neutrality: while at higher concentrations tolerance of acidity increases. There is also a marked correlation between acidity of the medium and the degree of branching of the roots, high acidity being associated with unbranched feeders.

Less of this type of work is being carried out than is desirable. Coffee is a slow-growing plant, and if adequate attention is paid to

field work the periods spent in Amani are rarely long enough to permit of cultures being grown for the time necessary to reach definite conclusions. African assistance, although excellent for many things, is not yet capable of the oversight of such work.

Spatial Root Distribution in the Soil.—A quantitative investigation of the spatial root distribution of four three-year-old coffee trees, has been carried out in the Arusha district. Radial sections, one foot in thickness, were made through each root system, and all the feeding roots therein counted and measured. From these data the total absorbing surface of the root systems can be calculated with reasonable accuracy. In addition, the distribution of the absorbing surface in the various soil horizons can be obtained.

The results should dispose of the prevailing misconception that *C. arabica* is essentially a surface rooting plant. They are awaiting publication.

Robusta Type Root Systems.—A start has been made with the investigation of the root systems of *robusta* coffees but, owing to the locust campaign, the pump was available for a short time only and consequently the work has had to be postponed. The effect of soil conditions on the rooting habit of *C. robusta* needs study, especially since considerable interest is being taken in the grafting of *arabica* scions on *robusta* and *liberica* stocks. A survey of the main *robusta*-growing districts is projected in 1935, somewhat on the lines of that carried out for *arabica*.

2. *Dieback studies.*

The hypothesis whereby dieback is ascribed to the depletion of the carbohydrate reserves by the developing crop still awaits adequate confirmation. A visit was made to the Arusha district during the 1933 cropping season for the purpose of obtaining additional evidence on dieback and more especially to study the time-relations of the phenomena involved. Unfortunately the experimental trees carried their crop successfully. Dieback did not take place: consequently its time-relations could not be elucidated.

Partial confirmation, however, was obtained. A relationship was shown to exist between the leaf crop ratio and the level of reserve starch, and as the crop matures the level of starch was shown to decline. These results are only roughly quantitative and it appears essential that the whole sequence of events be followed through with greater accuracy. As no field method appears to exist for the determination of starch in plant tissues, an attempt is being made, in conjunction with the Biochemist, to develop suitable technique. If successful, this should be available for the 1935 cropping season, as I shall be absent on leave during the season of 1934.

Although dieback did not take place in the experimental material, it was to be seen in the district. Adequate confirmation was obtained of the association of root damage with dieback, and of the depletion of reserve starch prior to loss of branches or of roots.

3. *Shade Experiment.*

The manurial treatment of this experiment, referred to in last year's report, restored the trees to magnificent vigour. A prolonged and severe series of attacks by leaf-miner followed. Up to the present no control measures have had the slightest effect in mitigating the severity of the infestation.

It is becoming apparent that the high incidence of pests and disease is making the usefulness of this experiment problematical. However, routine crop records, on an individual tree basis are being continued.

Sisal Investigations.

The standardization of sisal-testing has been carried a stage further. Standard methods have been adopted for sampling and for shuffling the samples prior to sub-sampling. A new testing-machine has been designed and made in Amani and, since its completion in September, over 50,000 tests have been made. From the data accumulated it has been found that differences of 6 per cent. can be shown and proved in the breaking strain and in the weight per unit length of fibre, on the basis of six sub-samples of approximately 100 fibres each.

The following criteria have been provisionally chosen as the measure of fibre characters :—

1. Average breaking strain of the individual fibre.
2. Average weight per unit length of fibre.
3. Actual cross-sectional area (on certain samples).
4. Average length of fibre and the frequency-distribution of length (on a basis of 3,000 fibres).

From the above can be calculated :—

5. Strength as expressed by 1 divided by 2, i.e., strength corrected for fineness of fibre on a weight basis.
6. Strength per unit cross sectional area, i.e., strength corrected for fineness on a dimensional basis.

These criteria are being obtained for fibres of various cuts from a range of East African estates, while samples from other sources are included for purposes of comparison. This will provide the essential background which will facilitate the evaluation of the fibre characteristics of selections or of exotic species.

The methods developed at Amani have been used for a study of variation in six seedlings of *Agave sisalana*. A wide variation of fibre characters exists, forming a further basis for selection. Further work for the Geneticist will be done so soon as facilities for the preparation of small samples of fibre become available.

It appears possible that the technical qualities of fibres may be capable of correlation with their physical qualities, bearing in mind the uses to which the fibre is to be put. It is already possible to indicate probabilities. For example, fibre with a high value of 5

would be expected to yield cordage with high tensile strength per unit weight, while a high value of 6 might well be associated with cordage having small diameter in relation to its strength.

It is obvious nevertheless, that without the co-operation of the manufacturer, correlation of performance with measurable physical qualities will be difficult, if not impossible.

No work on the sisal plant itself has been done this year.

F. J. NUTMAN,
Plant Physiologist.

REPORT OF THE PLANT GENETICIST.

Coffee.

The rainfall during the 1933 season was below average, but the 65 inches recorded was well distributed. Coffee plants of the *robusta* group have continued to make good progress, but the growth of varieties of *arabica* has continued disappointing. I am pleased to be able to report that facilities for growing selections of the latter species have been offered by the Department of Agriculture, Kenya, and the Coffee Research Station at Moshi.

A severe outbreak of Hemileia on *arabica* coffee and a very heavy leaf fall occurred during the year and this was closely followed by a severe attack of leaf miner. The latter also attacked the *robusta* coffees to a limited extent. The only pest at all serious on the latter species was a small borer, Xyleborus sp. which was responsible for a considerable loss of crop due to the severe pruning which was carried out in an attempt to control the pest.

Casualties among the seedlings raised from selfed seed of selected parents of *C. arabica* varieties have been so heavy that this work will have to be repeated during the coming season.

Study of the accumulating yield records for individual trees of *arabica* strains of coffee indicates that under the conditions prevailing at Amani the tendency is for a large proportion of the trees to give low yields. This cannot be accounted for entirely by the method of pruning which has been adopted, the single stem system, which tends to produce an umbrella-topped tree owing to the early loss of the lower primaries. The bearing surface of this type of tree is limited. A gradual change over to the multiple stem system has brought about a certain increase in yield, but there is still a very high proportion of the trees in the very low yielding categories. The yields of the moderately good trees are scattered over a very wide yield range.

The same tendency is found with *robusta* coffee, but it is not so marked.

Biennial bearing which is a feature of the old coffee in the district has not yet become apparent in the young plantations.

A number of hybridizations of *C. arabica* varieties have been made in the course of studies of the inheritance of bean size. Of the six interspecific crosses (*C. arabica* X *C. robusta*) made in 1931,

three have been successfully grown in the first generation. Two crosses produced seed which germinated but the plants have died subsequently. One of the latter in which the *robusta* characters were partly dominant has been repeated. It is interesting to note in this connection that in two of the crosses pollen from one *robusta* parent was used on two plants of *C. arabica* from the same strain (Jackson's). One of these crosses produced an F1 which is intermediate in some respects but bears a general resemblance to *C. arabica*, the other resembles *C. robusta*.

The three surviving families are of interest. Two families, one of seven plants (CB13), and one of fifteen plants (CB17) are being grown in boxes in the greenhouse. The third (CB10) is being grown in the field. During the past season this last family has made outstandingly good progress, vegetatively, compared with *C. arabica* grown on the same plot. A number of these plants have flowered several times but have all proved sterile. Pollination of some flowers with pollen from the male parent used in the original cross has also failed. Pollen germination tests have been carried out and a complete failure to germinate recorded. Control tests with pollen of *C. arabica* and *C. robusta* have shown good and rapid germination. Measurements of the diameters of the pollen grains show a much wider variation in the hybrid than is observed in either of the other species. Preliminary cytological examination of the pollen mother cell divisions of this hybrid show only one or two bivalents. As the hybrids show many desirable features attempts are being made to obtain tetraploid shoots from callused portions of the stem.

The fifteen plants of CB17 show considerable variation. Ten are of the *robusta* type, two *arabica* type, and three are dwarfed plants with small leaves having very much waved leaf margins. One plant of the latter class has produced a long main stem and only one short lateral branch at the fourteenth node whereas the others begin to form lateral branches quite normally at about the sixth node. Plants of this family are beginning to form flower buds.

The reciprocal crosses using the *robusta* as the female were generally unsuccessful. Two plants were obtained, one of which died after twelve months, development having ceased in the cotyledonary stage. The other plant has made good progress and resembles the *robusta* parent.

Little progress has been made with the study of compatibility and self sterility in *robusta* coffees. The isolation of plants of this species seriously reduces the yields. Complete records of yield are required before plants can be picked out for selection with any certainty, very little being known of the relationship existing between early yield and the yield of the mature plant, or the effect of age of the plants on the size of the bean.

Some of the early *robusta* selections and four plots of a first generation of inbred plants have come into bearing during the year. Among the latter, wide variation in bean character is noted.

The treatment of coffee cuttings with illuminating gas (Mansfield) and carbon monoxide in order to stimulate the production of adventitious roots has been tried on a small scale with poor success, but further work on these lines is projected. Layering of leading shoots has proved fairly successful, but the time taken to root the suckers arising from the axillary buds on the main stem has varied from six to twelve months. It is found that bud development must be started before the stems are earthed up. Various treatments of the young shoots to encourage rooting include wiring, ring-barking, and cleaving the base of the shoots. A proportion of the shoots treated by any of these methods have rooted, but the roots have proved very fragile and the rooted shoots have been difficult to establish after removal from the parent plant.

Coffee liquoring investigations have been continued and 68 samples of the 1932 crop were forwarded to the Imperial Institute for testing. Fifty-three samples have already been received and forwarded from the 1933 crop. The results so far obtained have been very confusing. The agreement between the results of the liquoring tests and the prices realized for coffee from the estates sending in the samples is not close. A series of tests have been carried out on the acidity of the coffee liquor and an attempt made to correlate the pH value with the score for acidity awarded by the tasters; the results are inconclusive.

Sisal.

Field work on this crop has been confined to recording observations on the development of plants of *A. sisalana*, the hybrids and seedlings of this species and other agaves.

Plants grown from bulbils and suckers of individual plants of *A. sisalana* show an appreciable variation in leaf number and leaf length after making due allowance for the variation due to position.

Frequency polygons showing the variation in leaf number for various lines of sisal bulbils and suckers have been drawn up and these all show a marked similarity in form. Sisal seedlings show a much wider variation but the form of the curve approximates to a normal distribution. The diagram obtained for the hybrid seedlings *A. angustifolia* X *A. sisalana* is similar to that of the sisal seedlings and differs widely from the form of the distribution shown for the selfed *A. angustifolia* seedlings, which is a very flat curve extending over a very wide range.

Continued efforts to induce seed production on *A. sisalana* have been made on plants growing locally and on the plains without success. Hand pollination has been effected in many cases but has only been followed by abscission of the flowers.

A study of the fibre content of the most promising seedlings of *A. sisalana* by making sections of the leaf has been continued. Ten

leaves of each of six of the best seedling plants (grown at Magunga Estate, Korogwe) were decorticated and the fibre tested by the Physiologist for fineness and strength. Nearly all the samples were finer and weaker than the average for first cut sisal. Further tests will be made as soon as a suitable decorticator is available.

A small experiment was laid down in March, 1933, to compare the development of *A. amaniensis* with that of *A. sisalana*. The sisal plots were planted with bulbils obtained from a single plant, and had been in the nursery 22 months. Counts of the rate of production of leaves and the increase in leaf length are made at intervals. At the end of March, 1934, the sisal bulbils had produced leaf at a slightly faster rate than the *amaniensis* suckers, but the leaf length of this species was greater than that of sisal. The total percentage increase in leaf number, compared with the original number of leaves per plant, is approximately the same in both series. Leaf counts have also been made on ten plants of each species grown on adjacent plots at Magunga. Both plots were planted at the same time with similar sucker material. The average leaf number for the *amaniensis* plants was 64·1 compared with 57·2 for sisal. The average leaf length of *amaniensis* was 115·3 cms. and exceeded that for sisal by 16·3 cms.

Eight plants of *A. amaniensis*, which have not had any leaf removed, have poled. A number of seed pods have been formed on the normal inflorescence. The maturing of these pods is awaited with interest. Three cases have been observed where suckers of these plants have poled at the same time as the parent and in all cases the small poles have developed directly from the terminal bud of the rhizome without the formation of the usual rosette of leaves at the point of emergence from the soil.

A number of species of agaves have been added to the collection, including *A. cantala*, *A. zapupe*, *A. miradorensis*, *A. bracteosa* and *A. "nirvana"** (*La Mortola*).

A cytological study of the available species of Agave has been started, but little progress has been made up to date.

General.

A few visits have been paid to various sisal estates in the Tanga district during the year and a week was spent on safari in the West Usambaras visiting coffee estates.

The conference at Amani in February afforded an opportunity for some very interesting discussions with officers of other departments engaged in work on coffee.

L. R. DOUGHTY,
Plant Geneticist.

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* An undescribed variety resembling *A. amaniensis*

REPORT OF THE SYSTEMATIC BOTANIST.

In the course of the year the following investigations and work were carried out in the Systematic Botany section :—

Herbarium.

A total of 1,953 specimens were identified and information supplied under the following heads :—

Botanical surveys in Tanganyika Territory.
Green manures and cover crop plants.
Host plants of insects and insect-transmitted virus diseases.
Ecology of pasture and grazing areas.
Browse and fodder plants, including grasses.
Plants suspected of being poisonous and used in cases of criminal poisoning.
Plants suspected of being harmful to stock.
Shade trees, and indigenous forest trees.
Food plants of locusts.
Famine food plants and indigenous herbs used by the natives as vegetables.
Botanical names of plants in connection with anthropological survey of the Wahehe.
Fish poison plants of possible interest as insecticides.
Essential oil, oil, gum, drug, and fibre plants.
Other economic plants, indigenous and exotic.
Parasitic plants.
Plants in relation to Bird and Tsetse Ecology.

Information on these subjects was supplied to the following correspondents among others :—

Department of Agriculture, Tanganyika Territory.
Department of Veterinary Science and Animal Husbandry, Tanganyika Territory.
Department of Tsetse Research, Tanganyika Territory.
Forestry Department, Tanganyika Territory.
Medical Department, Tanganyika Territory.
Police Department, Tanganyika Territory.
Department of Agriculture, Kenya Colony.
Department of Agriculture, Zanzibar.
Amani Staff.
Imperial Forestry Institute, Oxford.
Various individuals engaged in local agricultural industries and in agricultural research.

Of the plants received for identification, those suspected of being poisonous and used in cases of criminal poisoning, etc., were *Capparis lilacina* Gilg. (Capparidaceae), *Datura Metel* L. or *D. Stramonium* L. (Solanaceae) and *Phytolacca dodecandra* L'Herit. (Phytolaccaceae). It is well known that Datura is toxic and it is on record that *Phytolacca dodecandra* is harmful to stock,

but the Capparis had not hitherto been suspected. The Biochemist is investigating the toxic properties of the Phytolacca; unfortunately there was not enough material of the Capparis to analyse.

Among the parasitic plants received was a *Hydnora* (Cytinaceae), a fungus-like plant with a thick fleshy very warted subterranean rhizome, parasitic on the roots of Acacia and Baobab trees. It was causing considerable damage to Mwanza Hospital by the force which it exerted on obstructions when actively growing and producing its flowers. To quote from the Medical Officer, "Two of our wards recently developed serious cracks in the walls, and in one case the cement floor was gradually raised to a height of about 18 inches in one corner. Investigations showed abundant growth of this root at a depth of from 2 to 4 feet under the surface of the ground."

A 500-page report on the survey of the economic and other plants in the Amani Plantations has been completed and handed to the Director. It is a record of what plants were introduced by the Germans and where they were planted. With the aid of a card catalogue, a survival of the German days, I have been able to enumerate and trace the past history and present-day condition of some 1,220 species of exotic and indigenous plants that have been introduced into the plantations.

Further progress has been made with the recording of the native names of plants. Apart from personal enquiries, the index is being compiled from the following sources:—

(*a*) The native names recorded on German specimens in the Herbarium.

(*b*) Amani manuscript records.

(*c*) Publications containing native names with botanical equivalents.

(*d*) Manuscript records of the Forestry Department, Tanganyika Territory, by the kindness of the Conservator.

Up to date it is estimated that some 4,000 East African names with tribal origins and botanical equivalents have been accumulated, and the index is already proving to be of practical use.

Owing to pressure of other work it has not been possible to continue the identifications of the unnamed specimens in the German collections. There is still a considerable quantity of material to name up and distribute to other herbaria.

Type Species.

In the course of determining botanical material for various departments and individuals, 60 type specimens of different species were found in the Herbarium and recorded. The following new species from the Herbarium have been described:—

Lagynias littoralis Bullock & Greenway in Kew Bull. 1933, p. 148 (Rubiaceae) Pemba Island; Ngezi Forest, *Greenway* 2697, type.

Isachne aethiopica Stapf & Hubbard, l.c. p. 300. (Gramineae) T.T.; E. Usambaras, Amani, *Greenway* 1671, type.

Agave amaniensis Trelease & Nowell, l.c. p. 465, (Amaryllidaceae) Cultivated; Amani, *Greenway* 2391, type.

Disperma trachyphyllum Bullock, l.c. p. 476. (Acanthaceae) T.T.; Dodoma Province, Mpwapwa, *Greenway* 2391, type.

Brachyachne fibrosa C. E. Hubbard, l.c. p. 502, (Gramineae) T.T.; Iringa Province, Msima Stock Farm, *Emson* 349, type.

Crotalaria Greenwayii E. G. Baker in Journ. Bot. Dec. 1933, p. 339. (Papilionaceae) T.T.; Kilimanjaro District, Arusha Chini, *Greenway* 3012, type.

Crotalaria citriocolorata E. G. Baker, l.c. p. 340, (Papilionaceae) T.T.; Kilimanjaro District, between Moshi and Himo, *Greenway* 3010, type.

These seven new species brings the total number of type specimens recorded in the Amani Herbarium up to 171 types.

Contributions.

Fifty-six contributions were received during the year representing a total of 3,121 specimens. They were received from :—

The Department of Agriculture, Tanganyika Territory, communicated by the following officers :— Messrs. Davies (Tukuyu), Eyre (Tanga), Harris (Morogoro), Harvey (Moshi), Lock (Lushoto), Ritchie (Moshi), Rounce (Mwanza), and Stenhouse (Songea)	537
The Department of Veterinary Science and Animal Husbandry, Tanganyika Territory, communicated by the following officers :—Messrs. Hornby (Mpwapwa), Emson (Musoma) and Staples (Grassland areas of Tanganyika Territory)	209
Amani Staff	435
Royal Botanic Gardens, Kew	1,865
Medical Department, Tanganyika Territory ...	2
Medical Department, Tanganyika Territory, Sleeping Sickness Branch, collected by Dr. Maclean, communicated by Mr. B. D. Burtt	34
Tsetse Research, Tanganyika Territory, communicated by Mr. B. D. Burtt (including three types)	9
Dr. Gordon Brown, Iringa, Tanganyika Territory	20
Miscellaneous	10
Total	3,121

Exchanges.

Botanical material was exchanged with and distributed to the following institutions :—

From the Royal Botanic Gardens, Kew (including named East African material mainly collected in Kenya and Uganda) Total received	1,865
To the Royal Botanic Gardens, Kew (including a collection from Iringa Province, T.T.)	784
Imperial Forestry Institute, Oxford	148
Department of Veterinary Science and Animal Husbandry, Tanganyika Territory	27
Prof. W. Trelease, University of Illinois, U.S.A.	14
J. E. Spingarn, Esq., Amenia, New York, U.S.A.	9
Prof. E. B. Babcock, University of California, U.S.A.	7
The Chief Conservator of Forests, Tanganyika Territory	6
F. H. Smith, Esq., Department of Botany, University of Wisconsin, U.S.A.	3
Dr. J. Wiger, Halmstad, Sweden	1
The Director of Veterinary Services, South Africa	1
The Analytical Chemist, Medical Department, Tanganyika Territory	1
Total distributed	1,001

Loan of Specimens.

Specimens and types were loaned to :—

The British Museum	91 sheets of *Combretum* spp.
The Royal Botanic Gardens, Kew.	19 sheets of *Veronica* and Giant Senecio (returned).
The Royal Botanic Gardens, Kew.	16 sheets of Giant Lobelia (returned).
The Royal Botanic Gardens, Kew.	37 sheets of East African Gramineae.
Prof. E. B. Babcock, University of California, U.S.A.	7 sheets of *Crepis* spp.
Prof. W. Trelease, University of Illinois, U.S.A.	13 sheets of *Agave* and *Furcraea* spp.
The Senior Agricultural Officer, Mwanza, Tanganyika Territory.	3 sheets of *Dicoma anomala* (returned).

Field Work.

During a fortnight's invasion in December-January by swarms of Red Locusts (*Nomadacris septemfaciata* Serv.) the opportunity was taken to make observations on their food and feeding habits.

These may be compared with observations on the Desert Locusts (*Schistocerca gregaria* Forsk.) when swarms of that species visited the same area (Williams, *Ann. App. Biol.* XX, No. 3, pp. 466-471).

Consistent observation was not easy because the insects did not appear to be ravenously hungry, and most of them passed over to settle at a lower altitude. The first plants to be eaten were Gramineae, maize in a stage when the corn on the cobs was just beginning to swell, rice (at the lower altitudes), *Bambusa vulgaris* Schrad., *Chimonobambusa hookeriana* Nakai and a few other species.

When this supply had been exhausted their attention was turned to *Casuarina equisetifolia* Forst. and certain species of palms which were completely defoliated, with a number of Leguminosae, followed by bananas, coconut palms and certain varieties of Citrus and Cassava.

The unsatisfactory point about the observations is in connection with the latter group. For example, in many places bananas and coconuts were badly defoliated, while a short distance away these species were not touched at all. The same applied to Cassava and the indigenous grasses.

This may have been due in part to specific and varietal palatability as evidenced in the Amani banana variety plots, or to the particular climatic exposure of individual plants at the time the locusts were settling down for the night. This was observed on a windbreak of Avocado Pear trees in Amani. The trees were all of the same age and growth condition, but from 4 p.m. till sunset all except two lay in a shadow belt. The locusts began to collect in masses for the night between 3 p.m. and 5.30 p.m. and all the Avocado Pear trees were well covered with the insects.

The locusts appeared to be actively feeding on the two trees which were in the sun, and as the shadow began to move up over their foliage, the locusts climbed above it and continued to feed until the trees were in complete shade. As long as the insects were in Amani this continued, with the result that these two trees were completely defoliated, whereas those in the shadow belt were practically untouched.

Observations on the collection of native banana varieties are being continued. A considerable number have not yet fruited. The plot has suffered very greatly from the locust invasion and a long period of drought. The locusts were able to discriminate between the dessert and cooking types in that the best dessert variety, *Kisukari cha Kamba*, had every particle of leaf-blade eaten down to the mid-rib, whilst the other types were not devoured to the same extent.

From July to the middle of September was spent in travelling with the Soil Chemist in Iringa Province. Visits were made *en route* to the headquarters of the Agricultural Department at Morogoro

and the Department of Veterinary Science and Animal Husbandry at Mpwapwa as well as to the latter's stock farm at Misima River, Njombe.

All the areas open to European settlement were visited and a great variety of crops were seen such as maize, wheat, oats, rye, barley, peas, tobacco, tea, coffee, almonds, apples and pears, etc., some of which were only in an experimental stage of cultivation.

These areas were situated in vegetational types of great diversity, ranging from mountain grasslands, through dry Acacia-Combretum thorn bush, Berlinia-Brachystegia-Uapaca-Protea woodlands to evergreen rain and mist forest.

The mountain grasslands and the evergreen rain and mist forest types were of especial interest. The former covered great stretches of country which, no doubt, had been covered with evergreen rain forest in past times. Good examples of relics of rain forest in this grassland area were observed at Dabaga, Mufindi, Sao, and to a very limited extent at Njombe.

The most extensive block of evergreen rain and mist forest is found on the scarp extending from Dabaga through Mufindi to Lupembe, where some importance is attached to its presence as indicating areas suitable for the cultivation of tea and coffee.

It is doubtful if much of this forest area can in any sense of the word be called primary except for very scattered and isolated patches. There was distinct evidence of cultivation in past times in that the forest floor is ridged and a number of dominant species of trees are undoubtedly secondary, such as *Dodonaea viscosa* L. and *Lasiosiphon glaucus* Fresen.

The facts suggest that at one time the whole area was covered by primary rain forest which was removed, except for a few isolated areas, in the course of shifting cultivation, and that the area was in danger of complete deforestation. A change was then brought about in the habits of the people either by wars, pestilence, or famine, which caused them to cease cultivation. The areas with suitable climatic and edaphic factors have since been gradually re-afforested by the extension of the species from the island relics of primary forest.

By permission of the Director an extended local leave period was spent in February on Kilimanjaro. The sector from Marangu by way of Bismarck Hill, Peter's Hut to Kibo Hut was worked; further collections of plants, birds, and soil samples were obtained and different vegetational types from those found between the Umbwe and Weru Weru rivers were observed.

Requests for botanical material and seeds of indigenous plants from private individuals and institutions engaged on research work continue to be received. Material of this nature and about sixty

different kinds of seeds for trial at Amani has been collected and distributed to South Africa, United States of America, United Kingdom, Java, and Sweden.

Time has also been spent in the field on the native banana varieties trial, in the collection of botanical specimens and ecological data, together with information on the plants known and used by the natives in the Amani district.

P. J. GREENWAY,
Systematic Botanist.

ORNITHOLOGICAL WORK.

I.

During my leave the opportunity was taken to work at the British Museum, particularly on the Kilimanjaro collections, which it is proposed to describe. Through the kindness of Messrs. W. F. and T. A. Baldock and of Mr. P. J. Greenway, who allowed an African collector to be attached to them on recent safaris, it has been possible to obtain about one hundred more specimens from Kilimanjaro with good ecological notes. The avifauna of the mountain itself is now considered to be pretty exhaustively known; and the difference between the list for Kilimanjaro and that for the Usambaras, which are so near geographically, is surprising. Kilimanjaro is evidently much poorer in species and in endemics, notwithstanding its great size. Many of the species common to Usambara, Uluguru, and the mountains round the north end of Lake Nyasa are absent from Kilimanjaro, which can only be regarded avifaunally as a somewhat impoverished outlier of the Kenya Highlands. A paper is in preparation on the birds collected on Kilimanjaro in the last two years, their ecology, and the curious distributional problem the local lists present.

The Museum authorities suggested that, in continuation of the work done while in Egypt, I should collate the information obtained by recent expeditions in the Libyan Desert regarding the passage of Palaearctic migrants to and from their winter quarters in Eastern Africa. The material consisted partly of unpublished data and partly of records from Italian sources. Together they lead to a modification of views on migration in general through North-East Africa. The paper will appear in the *Ibis* under the title "A Contribution to the Ornithology of the Libyan Desert".

Owing to the difficulty of securing publication of a bulky series of papers in any one journal, it was found desirable to modify the projected series under the title "Contributions to Tropical African Bird-Ecology". A preliminary paper dealing with general principles has been accepted for the *Journal of Animal Ecology*, and "A Synecological Study of the Usambara Mountains with particular reference to the Birds" for the *Journal of Ecology*.

One new form has been described during the year from our collections :—

Nectariniidae Cinnyris mediocris moreaui, W. L. Sclater, from the Nguru Mountains, *Ibis*, 1933, p. 215.

An extensive search of the literature has been made for work having particular reference to tropical conditions and to East African birds. I make grateful acknowledgment of the library facilities afforded me at the Natural History Museum and at Glasgow University. It has become increasingly clear what vast fields of work lie almost untouched, especially on the biological and quantitative sides of ornithology, in East Africa, and indeed in the tropics as a whole. Much of the work can hardly be taken up except by residents. Situated as I am, my work must of necessity be very limited both in the area covered and in the time devoted to it. This opportunity is therefore being taken of indicating briefly certain lines on which anyone interested might usefully focus attention.

II.

Little has been accurately recorded of the distribution of birds in terms of environmental factors, mainly climate and vegetation. It is probable that the method of sample censuses can usefully be employed for comparing the relative (though not the actual) abundance of species in different associations.

The relation of birds to agriculture is an almost untouched subject. We do not know what birds are attracted by even the main East African crops and, as I have mentioned in an earlier report, this requires to be worked out for each stage of a crop and with reference to the surrounding natural conditions.

Except for a little work by Moreau and by Winterbottom, no attempt appears to have been made to ascertain the number of birds supported by unit areas of given types of country in Africa. The practical difficulties in the way of a satisfactory census are greater than in higher latitudes because breeding birds in pairs and in colonies, non-breeding birds alone or in itinerant parties, and in addition Palaearctic migrants, may all be present at once. In particular types of country, e.g., forest or coffee plantations, the difficulties may prove insuperable.

Nothing exact is known of the economic position of East African birds. But it is necessary to emphasize that except in a few species a reliable estimation must be difficult. Caution is particularly needed before pronouncing on the position of birds with an insect or a mixed diet. (For example, a proper examination of the food of the " Cattle Egret " in Egypt upset official pronouncements of several years' standing.) Even the vast experience of the United States Department of Agriculture has not sufficed to evolve a satisfactory method of assessing stomach-contents.

For preliminary work, especially in view of the slight possibilities of adequate entomological co-operation, it might be desirable

to concentrate on birds believed to attack grain in the ear; but even of their activities a balanced view can naturally only be arrived at after it has been ascertained what food, and what proportion of their total food, they obtain from natural sources, what food the immature birds receive, and during what proportion of the year young birds are being fed. These last questions lead us to breeding biology, many points of which are untouched for the most familiar species no less than for the rarities.

Even in Europe or North America, where the vast bulk of bird biology has been done, attention is only now being turned to the life history of individual birds. In the tropics this is a virgin field. But as in the tropics some species appear to be more fully sedentary than any birds in higher latitudes, there are exceptionally good opportunities for keeping track of individuals by marking them with coloured rings. Without such means we cannot establish definitely how many broods a year the same bird may bring up—and this certainly has never been done for many of even the British species that are recorded as having more than one brood a year. Systematic ringing of a sedentary tropical species might moreover give data on the degree of inter-breeding in wild birds The point is obviously of importance in the evolutionary process, but no body of data appears to exist for wild vertebrates under fully natural conditions.

Except for a very few incidental records no information appears to have been published on the fledging and incubation periods of tropical birds. For several seasons we have been attempting to collect data at Amani. The large number of nests which are pillaged at some stage before the young are ready to fly means a high percentage of wasted labour. But enough data have been collected to show that certain unexpected general tendencies exist.

Every clutch the history of which is followed provides data towards a knowledge of the species' average mortality in the nest. Such information as we have at present indicates that as between species the comparative mortality rates may be different from what might be supposed from the size of the clutches; so that adjustment must be effected in the subsequent life-history or by differential longevity.

Tropical breeding-seasons are altogether more variable as between species and more complicated than in birds of higher latitudes. Since the recent work of Chapin and Bates, the definition of breeding-seasons in East Africa lags behind that in West Africa. At present it is an open question what immediately initiates the breeding-impulse in the many tropical species showing periodicity. We want an accumulation of breeding-dates, especially for the same species in the same locality over a period of years, for critical discussion with reference to variation from year to year in the incidence of the rains, seasonal availability of foods, recrudescence of vegetation, abnormalities of temperature, etc.

No one appears to have tested the applicability to tropical birds of the theory of " territory " in bird-life, originally enunciated by Eliot Howard, very generally accepted by ornithologists, and recently reviewed by Lack (*British Birds*, 1933).

III.

Aside from the biology of East African birds, in which it is obvious that an unlimited field for work exists, there are certain areas that are insufficiently represented in collections. The desirability of filling up the blanks is emphasised because the preparation of a comprehensive work on East African birds, which is so badly needed, has been announced by Capt. C. H. B. Grant and Mr. Mackworth-Praed, in addition to the book based on the collections of Sir Frederick Jackson in Kenya and Uganda, which is being brought out by Mr. W. L. Sclater. So far as the British East African dependencies are concerned, the following are the areas from which material is most lacking in German and American as well as British collections :—

(Tanganyika as a whole is of course not well represented in the Natural History Museum.)

(*a*) The mountains on both sides of the Rift Valley between the Kenya border and Kondoa Irangi (including Oldeani, Mbulu, and Hanang). The avifauna of these mountains is practically unknown, and as they include peaks above 10,000 feet, with forest and bamboo belts, they represent as potentially interesting an area as any unworked in Africa.

(*b*) The Pare Mountains.—They are of particular interest because they form the link between Kilimanjaro and the Usambara Mountains, which recent work has shown to differ to a surprising degree in their birds.

I take this opportunity of emphasising the great extent to which the value of specimens collected depends on detailed particulars, especially of the environment, on their labels.

R. E. MOREAU.

REPORT OF THE SUPERINTENDENT OF PLANTATIONS.

Construction and Maintenance.

The chief item of this section has been the completion of the Plant Quarantine glasshouses.

The verandah on the west side of the Biochemists's laboratory has been glazed in, making a useful addition to the space available.

Roads.

The supervision and control of the Amani-Muhesa road was still maintained by the Station. The road has been kept in good order throughout the year. On no occasion was it found necessary to

close the road to light traffic. The usual closing to heavy traffic as a precautionary measure to avoid damage during the heavy rainy season was adhered to.

Transport.

The transport of the Station has been efficiently maintained. No new vehicles were purchased, and all repairs necessary were carried out in the station workshops.

Kwamkoro Coffee Estate.

The total crop for the year was 4½ tons of parchment coffee. Plantation work again consisted of cleaning through the *Coffee arabica* plantations with bush knives and the planting up of the previously prepared area with selected *C. robusta* from Amani. An area of approximately 12 acres has been prepared near the factory for the extension of the *C. robusta* plots.

Plantations and Nurseries.

Although the year was one of the driest for many years and was marked also by a week's heavy invasion of locusts, the plantations and nurseries were not seriously affected. The chief damage done by the locusts was the defoliating of palms, citrus and sugar-cane. Native food plants also, such as maize, bananas and cassava, were practically denuded of foliage throughout the whole of the district.

Five hundred plants of *Hydnocarpus wightiana* and 500 *Musa textilis* have been raised for distribution.

A small plot of *Aleurites montana* has been planted up from seeds obtained from the two trees left in the original seed beds. These trees are again fruiting and the extension of the plot is anticipated.

A large portion of the lower part of the Nursery was planted up with plots of five alternate rows of cassava cuttings taken from healthy and diseased plants for comparative yield tests for the Pathologist.

Cocoa.—A further 1,000 plants were raised during the year, making a total of 1,400 distributed to plantations in the Usambara district.

Cinchona.—Some 3,000 *Cinchona ledgeriana* seedlings have been raised for filling up the old Cinchona plots.

Tobacco.—Eight varieties of 29 selections and 3 hybrids were raised and approximately 2,000 plants planted out in the irrigation plots for the Pathologist.

Tea.—The poor types of tea plants have been cut out and the remainder pruned to bring the plants into condition for seed production.

Sugar.—A plot of each of the following varieties of sugar-cane has been planted :—P.O.J. 2727, BH 10/12, BA 11403, CO 205, CO 213, and RP 8. Cuttings of P.O.J. 213, P.O.J. 2714, P.O.J. 2725, and P.O.J. 2878 were obtained from the Tanganyika Planting Co., Moshi, and are growing well. The above does not include varieties undergoing quarantine.

Sisal.—Ten thousand seedlings of *Agave sisalana* have been raised from seed obtained from Longonot, Kenya, for the Geneticist.

A plot of land in the lower part of the Sigi plantations has been prepared for planting these during the coming rainy season.

The extension of the plots of *Agave amaniensis* to secure planting material for eventual distribution has been continued. For this purpose 2,500 suckers have been added to the Amani plots.

A plot of one acre has been planted with *Agave cantala* suckers, and sufficient bulbils of the same species planted up in the Nursery for adding an equivalent area as soon as they have rooted sufficiently. This planting material was obtained through the courtesy of the General Manager, Amboni Estate Ltd., from Mwera Estate.

A small plot of 240 plants of *Agave zapupe* and 11 plants of *Agave miradorensis* have been planted from bulbils obtained from the Botanic Gardens, La Mortola. A small collection of other *Agave* species was also obtained from the same source and added to the Nursery collection.

An experiment in the reproduction of sisal from leaf cuttings has proved interesting. Single leaves were cut from the parent plant, leaving a small portion of the main stem at the base, and planted in pure sand in the open. The following results were obtained :—

Rooted but no bud development ...	17
,, small development of bud ...	8
,, good bud development ...	70
,, two good buds developed ...	3
,, but bud development confined to original bud which had been cut in section ...	7
Total rooted	105
Not rooted and no bud development...	99
(N.B.—No buds in leaf axil.)	
Total planted	204

Coffee.—4,500 plants from selected *Coffea robusta* trees at Amani raised in the Nursery were planted out in the Kwamkoro plantation, while a further 5,000 plants are now ready for planting during the next rainy season.

Further experiments in vegetative propagation work have been continued. The shield grafting of *C. arabica* on one-year-old *C. robusta* stocks resulted in 25 per cent. only growing. The inarching of *C. arabica* seedlings on *C. liberica*, *C. excelsa*, and *C. Dybowski* seedlings again proved successful. The inarching of one-year-old *C. arabica* on one-year-old *C. robusta* stocks resulted in 100 per cent. success.

An experiment was also carried out inarching one-year-old *C. arabica* plants on 8-year-old *C. robusta* trees. For this purpose the *C. robusta* trees were stumped back to within 8-10 inches of the

ground. The *C. arabica* plant was then planted by the side of the base of the stump, and a strip of bark about 3 inches long and the width of *C. arabica* scion removed from the side of the stumped plant running downwards from the upper cut surface. An incision was then made in the scion at the level where the scion passes the upper surface of the stump, and a shield-shaped piece removed from the scion upwards towards the incision. This cut surface was then pressed into the channel in the bark of the stumped plant to form a close contact with the cambium of the stump and tied in position with raffia. No wax or other covering material was used. Although the difference in age of the scion and the stock was seven years, 65 per cent. success was obtained.

The development of shoots of *C. arabica* grafted on to ratoons from stumps of old *robusta* coffee is variable. Some of the few surviving grafts are very vigorous and bearing a second crop. A few plants showed signs of dieback during last season and were stripped and pruned.

A group of plants of *C. arabica* on *C. robusta* root stocks, inarched as seedlings, planted in the field in May, 1933, show variable development. Casualties amount to 27 per cent. of the plants set out. The majority show more vigorous growth than would be expected from *arabica* seedlings growing on their own roots in this district.

A portion of the nursery has been set aside as a permanent site for a collection of grafted and inarched plants. On this plot *arabica* coffee is grafted on to *robusta*, *congensis*, *quillou* and *liberica* stocks. A few deaths have occurred, but the majority of plants have made very good progress; a number inarched as seedlings in February, 1932, are bearing a crop this season.

Outstanding among the plants in the collection are six shield grafts of *arabica* on *liberica* root stocks. The grafts were made when the stocks were about eighteen months old and subsequent development has been very vigorous; similar material on other root stocks is, however, not available for comparison.

Plant and Seed Introduction.

162 packets of seeds.
3 lb. *Agave sisalana* seed.
250 bulbils *Agave zapupe*.
20 bulbils *Agave miradorensis*.
38 bulbils *Agave sisalana*.
14 plants *Agave* species.
1,000 suckers *Agave cantala*.
1,000 bulbils *Agave cantala*.
9 plants *Coffea stenophylla*.
6 plants *Craibia Elliotii*.
40 suckers *Ananas sativus* (Hawaiian Pineapple).
*4 varieties sugar-cane.

* Introduced from local source and not including varieties introduced from other countries now undergoing quarantine.

Plant and Seed Distribution.

232 packets of seeds.

12¼ lb. Coffee seed.

110 lb. Kapok seed.

100 lb. Tea seed.

50 lb. *Maesopsis Eminii* seed.

25 lb. *Cassia siamea* seed.

28½ lb. of miscellaneous seeds, including cover crops and temporary shade trees.

1,400 Cocoa plants.

226 individual and 20 boxes of miscellaneous plants.

105 lb. Ginger rhizomes.

250 suckers *Agave amaniensis*.

2 boxes *Cinchona ledgeriana* seedlings.

116 bulbs, roots and rhizomes of miscellaneous plants.

2 cwt. *Boehmeria nivea* var. *tenacissima* root divisions.

420 cuttings.

F. M. ROGERS,
Superintendent of Plantations.

REPORT OF THE SECRETARY AND LIBRARIAN.

During my absence on leave the office work was carried on by the Assistant Secretary. He was assisted in the Library by Mr. Nichols. Owing to the lack of typing staff, the card indexing that forms so important a part of the Library work had to be suspended, but it has been resumed recently and arrears have been made up.

Owing in part to the curtailment of Research Station expenditure in the period of uncertainty towards the end of 1933, the number of books added to the Library during the year is only 43. Scientific workers in East Africa are beginning to avail themselves of the loan facilities the Library offers.

The secretarial work in connection with the East African Conference on Plant Protection and Coffee Research (February, 1934) was carried out by the Research Station office staff.

R. E. MOREAU,
Secretary and Librarian.

APPENDIX A.

FINANCIAL STATEMENT FOR THE YEAR 1933.

Revenue.

Ordinary Recurrent Revenue :—	£	£
Contribution, Empire Marketing Board	6,000	
,, Tanganyika Territory	6,000	
,, Uganda	1,800	
,, Kenya	1,700	
,, Zanzibar	1,200	
,, Northern Rhodesia	300	
,, Nyasaland	300	
	17,300	
Local Sales &c....	239	
Total Recurrent Revenue		17,539
Extraordinary Revenue :—		
Levy on Salaries	614	
Sale of Cinchona Bark	366	980
		£18,519

Expenditure.

	£	£
Personal Emoluments	10,426	
Passages	837	
Pensions Contributions	1,885	
Laboratories	698	
Library and Publications	383	
Office, Telephone Rent and Contingencies	189	
Materials	303	
Freight and Transport	207	
Travelling	570	
Labour	1,146	
		£16,644

Summary.

	£
Recurrent Revenue	17,539
Extraordinary Revenue	980
Credit Balance on 1st January 1933 as finally agreed with the Treasurer, Tanganyika Territory.	1,180
Total	19,699
Expenditure	16,644
Credit Balance on 31st December, 1933	£3,055

On the subject of the under-expenditure on maintenance and the disposal of part of this credit see the note in the Director's Report.

Kwamkoro Coffee Estate.

Revenue.	£	£
Sale of Coffee (mostly 1932 Crop)		1,105
Expenditure.		
Crop Expenses:—	£	
Labour	40	
Materials	15	
Freight and Transport	26	
	81	
Other Expenses:—		
Maintenance Labour	210	291
		814
Excess of Expenditure over Revenue in 1932		60
Balance		£754

N.B.—The balance of the 1933 crop, which was expected to realise about £120 net will be credited in the 1934 accounts.

APPENDIX B.

LIST OF PUBLICATIONS BY EAST AFRICAN AGRICULTURAL RESEARCH STATION.

1. Records of Butterfly Migration in East Africa. C. B. Williams, *J. E. A. & Uganda Nat. Hist. Soc.*, No. 35, pp. 1-16, 1929.
2. Collected Records relating to Insect Migration. C. B. Williams, First and Second Series, *Trans. Ent. Soc., London*, Vol. 77, pp. 79-91, 1928; Vol. 79, pp. 139-170, 1930.
3. Locust-hoppers and Birds in East Africa. R. E. Moreau, *Bull. Ent. Res.*, Vol. 21, Part 2, pp. 141-145, 1930.
4. The Bird-population of a Settled Valley in the West Usambaras, Tanganyika Territory. R. E. Moreau, *J. Ecol.*, Vol. 19, No. 1, pp. 64-74, 1931.
5. The Filtration of the Virus of Streak Disease of Maize. H. H. Storey, *Ann. Appl. Biol.*, Vol. 19, No. 1, pp. 1-5, 1932.
6. The Estimation of Carbon in Plant Tissues. R. R. Worsley & F. J. Nutman, *Ann. Bot.*, Vol. 45, No. 180, pp. 693-707, 1931.
7. A Bark Disease of Coffee in East Africa. H. H. Storey, *Ann. Appl. Biol.*, Vol. 19, No. 2, pp. 173-184, 1932.
8. Vegetation of Mpwapwa, Tanganyika Territory. P. J. Greenway, *J. Ecol.*, Vol. 21, No. 1, pp. 28-43, 1933.
9. Pleistocene Climatic Changes and the Distribution of Life in East Africa. R. E. Moreau, *J. Ecol.*, Vol. 21, No. 2, pp. 415-435, 1933.

10. On the Food of the Red-billed Oxpecker. R. E. Moreau, *Bull. Ent. Res.*, Vol. 24, Part 3, pp. 325-335, 1933.

11. The Inheritance by an Insect Vector of the Ability to Transmit a Plant Virus. H. H. Storey, *Proc. Roy. Soc. B.*, Vol. 112, pp. 45-60, 1932.

12. A Sulphur-deficiency Disease of the Tea Bush. H. H. Storey, *Ann. Appl. Biol.*, Vol. 20, Part 1, pp. 23-56, 1933.

13. A Note on the Distribution of *Gypohierax angolensis* (Gmel.), the Vulturine Fish-eagle. R. E. Moreau, *J. Animal Ecol.*, Vol. 2, No. 2, pp. 179-183, 1933.

14. Observations on the Desert Locust in East Africa from July, 1928, to April, 1929. C. B. Williams, *Ann. Appl. Biol.*, Vol. 20, No. 3, pp. 463-497, 1933.

15. A Contribution to Tropical African Bird-Ecology. R. E. Moreau, *J. Animal Ecol.*, Vol. 3, No. 1, pp. 41-69, 1934.

16. A Chemical Survey of the Waters of Mount Meru, Tanganyika Territory, especially with regard to their qualities for Irrigation. D. Sturdy, W. E. Calton & G. Milne, *J. E. A. & Uganda Nat. Hist. Soc.*, No. 45, pp. 1-38, 1933.

17. Investigations of the Mechanism of the Transmission of Plant Viruses. H. H. Storey, *Proc. Roy. Soc. B.*, Vol. 113, pp. 463-485, 1933.

18. Root-systems of Coffea arabica, Parts I and II. F. J. Nutman, *Emp. J. Exp. Agric.*, Vol. 1, pp. 271-284, 285-296, 1933.

19. Taxonomic and Field Notes on Some Birds of North-East Tanganyika Territory. W. L. Sclater and R. E. Moreau, *Ibis* (Ser. 13, Vol. 2), pp. 487-522, 656-683, 1932; (Ser. 13, Vol. 3) pp. 1-33, 187-219, 399-440, 1933. (Limited distribution only.)

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